# The pH Game

## Purpose

To teach students about the acidity levels of liquids and other substances around their school so they understand what pH levels tell us about the environment

## Overview

The pH game will engage students in the measurement of the pH of water samples, soil samples, plants and other natural materials from different places. Students will create mixtures of materials in order to collect different pH measurements.

## Student Outcomes

Students will identify the pH of common substances, learn how high or low pH levels may result in dangerous conditions in the environment, and examine how pH may be changed.

*Earth and Space Science*

Water is a solvent.

Each element moves among different reservoirs (biosphere, lithosphere, atmosphere, hydrosphere).

*Physical Science*

Objects have observable properties.

*Scientific Inquiry Abilities*

Develop explanations using observations.

Recognize and analyze alternative explanations.

Communicate procedures and explanations.

Use instruments to gather data accurately.

## Time

One class period for preparation

One class period for the game

## Level

All

## Materials and Tools

*For each team: (about 4 students)*

20 pH strips

3 to 5 small cups

Paper and pencil

Labels to attach results to results board

*For the class:*

Results board (one line of pH levels from 2 to 9 for each team)

Flip chart with rules

Additional pH strips

Cups of solutions prepared for analysis

## Preparation

Gather materials for pH solutions.

## Prerequisites

Discussion of lab safety procedures

# Teacher Support

## *Introduction*

The level of acidity (pH) significantly influences the vegetation and wildlife in an environment. The pH can be influenced by different factors. The main natural influences are the contributions from rocks and soils. Human activities can also contribute, by releasing basic or acidic substances into the air, water or ground. One particularly important contribution from human activities is acid rain (which forms when acidic compounds released into air combine with water in the atmosphere). Acid rain can lower the pH in water bodies to levels that are dangerous to certain species.

It is important to understand pH. This activity will help your students understand the pH scale. More advanced students will mix acid and basic solutions to produce solutions of intermediate pH, and will also learn about the relationship between alkalinity and pH.

## *Advance Preparation*

You or your students should prepare various acidic and basic mixtures/solutions of natural and processed materials. These solutions should be labeled with the ingredients and a letter, but not their acidic or basic characteristic. Examples of acidic solutions include fermented grass, dilute and concentrated lemon juice, black coffee, vinegar, orange juice, and soft drinks. Basic solutions include salt water, shampoo, baking soda, chlorine bleach, household ammonia, and oven cleaner. Local water and soil solutions should be used as well. Soil water solutions are produced by mixing equal amounts of distilled water with soil, and then allow the soil particles to settle out. You can also produce solutions from materials found around the local school area, such as oil drippings from a vehicle, liquid in a discarded bottle, etc.

*Table HY-pH-1*

| | pH Value | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Teams** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **TOTAL** |
| Team 1 | | | | | | | | | |
| Team 2 | | | | | | | | | |
| Team 3 | | | | | | | | | |

*Table HY-pH-2*

| | pH Value | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Teams** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **TOTAL** |
| Team 1 | 1 | | 1 | | | 1 | 1 | | 4 |
| Team 2 | | 1 | | 1 | | | | 1 | 3 |
| Team 3 | 1 | | | | 1 | | 1 | | 3 |

## What to Do and How to Do It

Remind students of the difference between hypothesis and results. Encourage them to develop their hypothesis and find a way to test it with results. The *Implementation Guide* for Teachers in the *GLOBE Teachers Guide* contains materials on guiding students in research. Divide your class into separate teams.

## The Rules

1. Explain that the objective of the game is for each team to identify solutions that have a pH range of 2-9.

   The students should draw a horizontal pH scale line from 0 to 14, marking pH 7 as the neutral point. Each unit should be spaced at least 1 cm apart. They should then draw a box underneath each pH unit from 2 to 9.

   Each team finds substances that have a pH corresponding to a box in the pH scale.
2. The teacher draws the following matrix on the board. See HY-pH-1.
3. One point is awarded for each box filled, even if the team finds two samples with the same pH.
4. Students should record all the information about the solution from the labels and the pH they measured.
5. When students are ready to submit a sample for the game results board, they show the teacher their notes and sample. Together they measure the pH with a new pH strip. If the pH agrees with the students' previous measurement, the sample is approved and the points are added to the team's score. The Table HY-pH-2 is an example of results for different teams.
6. The teacher gives a new pH strip for each sample added to the results board.

## Extensions to the pH Game

### Beginning

For a basic understanding, use salt and sugar and explain to students that salty does not necessarily mean acid and that sweet does not necessarily mean basic. Cola soft drinks are good examples of a sweet and very acid liquid.

### Intermediate

Make the game more competitive. For instance, the team that finds or creates the first sample of a particular pH value receives 5 points; subsequently, samples for that pH level receive only 1 point.

Make the game more difficult by limiting the sample sources to only natural materials.

Limit the number of pH strips given to each group and set up a rule for buying a new one with game points.

### Advanced

Ask the student which solutions should be mixed together to produce a neutral solution (pH ~7). Explain to the students that pH is a logarithmic scale and is not additive. (For example, mixing equal amounts of unbuffered solution of pH 6 and pH 7 would produce a solution of pH 6.2, not pH 6.5, although if they are using pH paper, they will not be able to tell the difference.). Have them test their hypothesis by mixing some of the labeled solutions together and recording the pH. How much of each solution was used? What was the resulting pH? Is it higher or lower than then expected?

Explain the concept of acid neutralizing capacity (alkalinity). Discuss whether it requires more acidic solution to lower the pH of a solution with high alkalinity or a solution with low alkalinity, when both solutions have the same starting pH. Many of the solutions may have some alkalinity; therefore a higher proportion of the acidic solution will be required to lower the pH of the solution with higher alkalinity. Have students discuss the neutralization capacity of the different solutions. Relate this to buffering capacity (alkalinity) of hydrology sites.

Conduct a similar analysis of samples made from water from different areas of your community. Compare tap water compare with water from your study site. Compare the pH of water mixed with soil from different soil horizons.

**Note:** For older students we recommend inviting an expert to answer their questions.

## Further Investigations

Examine the Hydrology Study Site for materials in soil, rocks, and vegetation that influence the pH of the water.

Try to identify and quantify influences that are not always present at the study site, such as precipitation or some event upstream of your sampling site. See if the pH of your site changes over the course of a day. Photosynthesis can cause fluctuation in pH (although these will be too small to be measure with most pH paper)

## Student Assessment

After the game sit with students around the results board and identify what samples they have found, where the samples were found, and the pH of the samples. Encourage students to present their own ideas about why different samples have different pH values. Emphasize differences among water samples from soils, rocks, artificial surfaces, lakes, rivers, etc. Mention the acid neutralization capacities (alkalinity) of some rocks and the acidic influences of different materials. Ask them why it was difficult to find samples for some pH levels and easy to find others.

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